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ABSTRACT

This publication provided the competencies and key indicators for a program that enables students to prepare for a number of occupations within the broader metalworking industry. Specializations include machinist, computer numerical control programmers, and maintenance and machine builders. Competencies and the related key indicators are presented for these 11 units: orientation to the precision machining technology industry; safety in the machining industry; measuring workpieces, drawing interpretation, and inspection; benchwork and layout; power saws; drilling machines; lathes and turning machines; milling machines; grinding machines; computer numerical control; and job planning and management. (YLB)

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Overview
Precision Machining Technology

The Precision Machining Technology program enables students to prepare for a number of occupations with the broader metalworking industry.

One area of specialization is a Machinist. They set-up and operate a variety of machine tools to produce precision parts and instruments. It includes precision instrument makers who fabricate, modify, or repair mechanical instruments. Machinists may also fabricate and modify parts to make or repair machine tools or maintain industrial machines, applying knowledge of mechanics, shop mathematics, metal properties, layout and machining procedures. Related occupations that require similar knowledge, skills and work activities are: materials inspectors, mechanical inspectors, mechanical engineering technicians, model makers (metal and plastic), millwrights, precision devices inspectors and testers, engine and other machine assemblers, welder-fitters, and aircraft systems assemblers.

Another area of specialization is Computer Numerical Control (CNC) Programmers.

They develop programs to control machining or processing of parts by automatic machine tools, equipment or systems. Related occupations are: mathematical technicians, mold makers (metal and plastic), computer numerical control machine tool operators and tenders (metal and plastic), computer security specialists, data processing equipment repairers.

Still another area of specialization includes maintenance and machine builders. They perform work involving the skills of two or more maintenance or craft occupations to keep machines, mechanical equipment, or the structure of an establishment in repair. Duties may involve pipefitting, boiler making, insulating, welding, machining, repairing electrical or mechanical equipment, installing, aligning, and balancing new equipment.

The professional organization for machinists is the National Institute for Metalworking Skills, Inc. (NIMS). NIMS have developed skill standards for the industry. These are benchmarks for performance and define the competencies for workers in the metal workworking industry.

NIMS provide a credentialing program that recognizes that a person's competencies have been validated against a set of industry-written skill

standards. Skill certification is a two-step process that involves meeting the performance requirements and passing a knowledge skills exam required for the credential. The performance requirements and the exam are the same nationwide. Thus, the credential is portable.

Precision Machining Technology

Acknowledgements

Overview

1. Orientation to the Precision Machining Technology Industry
2. Safety in the Machining Industry
3. Measuring Workpieces, Drawing Interpretation, and Inspection
4. Benchwork and Layout
5. Power Saws
6. Drilling Machines
7. Lathes and Turning Machines
8. Milling Machines
9. Grinding Machines
10. Computer Numerical Control
11. Job Planning and Management

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Unit 1: Orientation to the Precision Machining Technology Industry

L-1, 5.1, 5.2, 5.3, 6.1, 6.2

Competency: Define machining industry

1. Present an overview of the machining industry
2. Identify professional and/or trade associations related to the machining trades
3. Identify areas of specialization and related occupations within the machining trades
4. Identify employment opportunities in the machining trades

Competency: Determine skills needed to work in the machining industry

1. Match machining occupational job titles with qualifications and responsibilities
2. Identify education and training required to work in various machining careers
3. Describe kinds of work techniques, processes' and procedures a typical machinist might perform

Unit 2: Safety in the Machining Industry

Competency: Maintain personal safety

1. Wear eye, ear, and respiratory protection according to Occupational Safety and Health Administration (OSHA) guidelines
2. Identify lock-out/tag-out procedures
3. Wear hand and foot protection according to OSHA guidelines
4. Wear clothing considered safe according to OSHA guidelines
5. Confine long hair
6. Remove jewelry
7. Follow established procedures for use of fire extinguishers
8. Follow established procedures for handling blood-borne pathogens
9. Identify location of fire alarms and exits
10. Report injuries to supervisor
11. Maintain work stations in accordance with standards for cleanliness and safety
12. Adhere to directions given on Material Safety Data Sheet (MSDS) labels on hazardous materials
13. Interpret personal safety rights according to shop's Right-to-Know Plan

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Competency: Protect workers from ergonomic injuries

1. Identify work practices that insure healthy ergonomic practices
2. Identify repetitive motion activities that might cause injury
3. Maintain posture to prevent injuries

Competency: Maintain tools and equipment

1. Practice general housekeeping and maintenance procedures for tools and equipment
2. Perform visual checks of grounding and cord condition on all machinery
3. Lock-out/tag-out mechanical equipment for repair and/or maintenance
4. Demonstrate care and maintenance procedures for each hand tool and machine, and related equipment
5. Check mounting of all safety shields and/or machine guards for compliance with OSHA guidelines
6. Store tools in accordance with shop policy

Unit 3: Measuring Workpieces; Drawing Interpretation, and Inspection

Competency: Demonstrate basic shop math skills

1. Apply basic math skills (e.g., addition, subtraction, multiplication, division, decimals, fractions)
2. Interpret tables and formulas in machinery handbooks
3. Manipulate simple formulas and algebraic equations
4. Perform calculations using geometric functions
5. Perform calculations using right-angle trigonometric functions
6. Perform trigonometry calculations using a scientific hand calculator

Competency: Interpret different measuring systems

1. Demonstrate knowledge of English system of measurement
2. Demonstrate knowledge of metric system of measurement
3. Demonstrate knowledge of measurement standards and fit designations
4. Convert measurements from metric to English system and English to metric

Competency: Use measuring tools

1. Demonstrate knowledge of applications/functions of each basic measuring tool
2. Select appropriate measuring tool for a given job
3. Make linear measurements using a steel rule
4. Make a variety of measurements using a combination square
5. Check accuracy of thread size and pitch using a thread-pitch gauge
6. Locate center of a workpiece using a center head
7. Check accuracy of drill-point angle using a drill point gauge
8. Measure angles using a bevel protractor

9. Measure depth for a groove hole, recess, or step using a depth gauge
10. Make internal measurements using a small-hole gauge
11. Make internal measurements by using a telescoping gauge
12. Measure internal dimensions using an inside micrometer
13. Measure external dimensions using an outside micrometer
14. Measure internal and external dimensions and surface depth using a dial caliper
15. Measure depth of a feature using a depth micrometer
16. Measure angular surfaces using a sine bar and gauge block
17. Check sizes, measurements, and alignment against a known standard using a dial indicator and a height gauge
18. Check hole diameters and bores using a dial bore gauge
19. Verify measuring tool accuracy using Jo blocks, pin gauge, and/or standards
20. Maintain measuring tools (e.g., clean, calibrate)
21. Demonstrate knowledge of characteristics and functions of Go/No-Go gauges
22. Demonstrate knowledge of characteristics and functions of snap gauges
23. Demonstrate knowledge of characteristics and functions of taper plug gauges
24. Demonstrate knowledge of characteristics and function of thread gauges

Competency: Interpret blueprints

1. Identify common drafting symbols
2. Identify types of information found in blueprint title block
3. Identify types of views shown on blueprints
4. Locate needed views (top, front, side) of an object
5. Identify different lines types (i.e., center lines, visible lines, hidden lines, dimension lines, phantom lines)
6. Interpret blueprint lines
7. Differentiate between object and hidden lines
8. Interpret section views
9. Identify industry method for showing dimensions and tolerances
10. Identify types and methods of screw thread representation
11. Identify surface texture symbols and processes associated with them
12. Interpret blueprint symbols commonly used in geometric dimensioning and tolerancing
13. Sketch workpieces

Competency: Check accuracy of parts against print specifications, dimensions,

and tolerances

1. Inspect rectangular, round, angular, workpieces for compliance with print specifications, dimensions, and tolerances (e.g., flatness, squarness, parallelism, perpendictability)
2. Inspect internal dimensions for compliance with print specifications, dimensions, and tolerances

Unit 4: Benchwork and Layout

Competency: Perform basic layouts according to print specifications,

dimensions, and tolerances L-1, 2.1 & 2.2

1. Lay out/transfer measurements using a combination square
2. Mark center of round stock using center head of a combination square
3. Lay out angles using protractor head of a combination square
4. Layout/transfer measurements using a machinist's square
5. Lay out/transfer linear dimensions using a scriber, divider, and trammel
6. Lay out/transfer linear measurements using layout dye and a surface gauge
7. Lay out angles using a sine bar and gauge blocks
8. Locate positions using a center punch
9. Establish reference surfaces using a surface plate
10. Secure workpieces at variable heights above a surface plate using parallels
11. Measure angular surfaces using angle gauge blocks
12. Secure workpieces in position using V-blocks
13. Secure workpieces in position using clamps
14. Secure workpieces in position using an angle plate

Competency: Use hand tools according to Occupational Safety and Health

Administration (OSHA) guidelines L-1, 2.1, 3.1,4.1, & 5.1

1. Follow established safety and maintenance procedures for hand tools
2. Select work-holding device appropriate for a given job
3. Select appropriate tools for a given job
4. Install hacksaw blades
5. Drive pins, bolts, or parts using a pin punch
6. Transfer hole locations using a transfer punch
7. Transfer location of threaded holes using transfer screws
8. Mark workpiece for centering layout work
9. Mark parts using handstamps
10. Finish and deburr workpieces using hand tools (e.g., file, scraper)
11. Hand-sharpen cutting tools
12. Identify procedure for removing a broken bolt
13. Identify procedure for removing a broken drill

Competency: Use hand power tools according to OSHA guidelines

1. Follow established safety and maintenance procedures for hand power tools
2. Drill holes using a hand power drill
3. Cut materials using an abrasive cutoff wheel

Competency: Cut threads using a tap and die L-1, 2.1 & 3.1

1. Identify thread uses and class of fit
2. Identify parts of a thread
3. Specify thread designations
4. Interpret thread designations
5. Measure screw pitch and diameter

6. Cut external threads using a die and die stock
7. Identify tap specifications
8. Cut internal threads using a tap and tap wrench
9. Identify tap drill sizes
10. Identify applications for oversized tapping

Competency: Use arbor presses L-1, 2.1

1. Identify safety issues related to use of arbor presses
2. Assemble/disassemble workpieces using an arbor press
3. Broach keyways using a broaching set and arbor press
4. Select tools needed in using arbor press for assembly work

Competency: Demonstrate knowledge of materials being machined

1. Interpret terminology associated with materials and their machinability
2. Identify types of metals and related materials
3. Distinguish between ferrous, nonferrous, and nonmetallic materials
4. Identify heat-treating methods for use with various materials
5. Identify factors that affect cutting speeds and feeds

Competency: Apply knowledge of heat-treating processes

1. Interpret terminology associated with heat-treating
2. Identify methods for testing hardness
3. Identify heat-treating processes on various materials

Unit 5: Power Saws

Competency: Perform preventive maintenance on power saws according to manufacturers' specifications L-1, 2.9

1. Follow established safety procedures for power saw maintenance (i.e., clean/lubricate power saws)
2. Check power saws and blades for wear and alignment
3. Adjust coolant flow

Competency: Operate power saws according to manufacturers' specifications

L-1, 2.9

1. Identify various types of power saws and their applications
2. Identify blade principles and configurations for power saws
3. Identify/install proper saw blade
4. Establish speeds, feeds, and cutting fluids used with power saws using shop

formulas and charts
5. Identify factors to consider in using cut-off saws
6. Identify work-holding practices for cut-off saws
7. Select power saw appropriate for a given job
8. Select blade appropriate for a given job
9. Secure workpieces
10. Install blades
11. Follow established break-in procedures for saw blades
12. Set cutting speeds and feeds using shop formulas and charts
13. Test-run blades to check alignment and direction
14. Cut material to length according to blueprint specifications
15. Cut straight lines
16. Make angular saw cuts
17. Make internal saw cuts
18. Make contour saw cuts
19. Saw internal contours using a band saw
20. Coil/uncoil band saw blades
21. Check first piece for batch sawing
22. Check parts in process
23. Adjust cutting fluid flow
24. Deburr workpieces
25. Inspect workpieces for compliance with engineering drawings and job specifications
26. Mark workpieces for future identification
27. Cut blades
28. Weld blades
29. Store blades

Unit 6: Drilling Machines

Competency: Perform preventive maintenance on drilling machines according to manufacturers' specifications L-1, 2.8

1. Follow established safety procedures for drilling machine maintenance
2. Clean/lubricate drilling machines
3. Check drilling machines for wear and alignment

Competency: Sharpen drill bits to specified geometry L-1, 2.8

1. Follow established safety procedures for sharpening drill bits
2. Determine drill geometry for material
3. Select grinding wheel appropriate for a given sharpening task
4. Dress grinding wheels
5. Grind drill bits to drill gauge

Competency: Mount workpieces L-1, 2.8

1. Identify main types of work-holding devices
2. Select work-holding device appropriate for a given job
3. Mount/align work-holding devices

4. Follow proper clamping procedures
5. Position workpieces using V-blocks and angle plates
6. Secure workpieces

Competency: Operate drilling machines according to manufacturer's specifications L-1, 2.8

1. Identify major types of drilling machines and their uses
2. Identify major parts of a drill press
3. Identify cutting tools used for drill press operations
4. Select drilling machine appropriate for a given job
5. Follow shop safety guidelines for drilling machine operation
6. Set drilling feeds and speeds using shop formulas and charts
7. Change chucks and sleeves
8. Secure drills using a drill chuck and key
9. Remove drills using a drill drift
10. Apply coolants
11. Use center drills
12. Drill workpieces to specified sizes
13. Ream holes
14. Counterbore holes
15. Countersink holes
16. Spot face holes
17. Chamfer workpieces
18. Inspect workpieces for compliance with engineering drawings and job specifications

Unit 7: Lathes and Turning Machines

Competency: Demonstrate basic knowledge of lathes

1. Identify established safety procedures for lathes and turning machines
2. Interpret terminology associated with lathes
3. Identify types of lathes
4. Identify parts and subparts of a lathe
5. Identify applications of specific lathe accessories

Competency: Demonstrate knowledge of general maintenance procedures (manufacturers' specifications) for lathes and turning machines L-1, 2.4

1. Identify general housekeeping and maintenance procedures for lathes and turning machines
2. Identify preventive maintenance procedures for lathes and turning machines (e.g., oils, coolants, gibs)
3. Identify tooling maintenance procedures for lathes and turning machines

Competency: Grind cutting tools L-1, 2.4

1. Select grinding machine and wheel type appropriate for a given job
2. Select tool blank appropriate for a given job
3. Grind tool blanks to specified geometry
4. Differentiate between hand-ground and insert-type tooling geometries

Competency: Set up turning operations L-1, 2.4

1. Identify common turning operations
2. Identify basic shapes of indexable/single-point cutting tools
3. Compare advantages and disadvantages of carbide and high-speed steel cutting tools
4. Follow established safety procedures for use of lathes and various turning machines
5. Select work-holding device appropriate for a given job
6. Mount work-holding devices (chuck, face plate, collets)
7. Demonstrate methods for mounting workpieces between centers and onto mandrels
8. Secure workpieces
9. Identify types of tool posts and toolholders and their uses
10. Select toolholders and inserts according to American National Standards Institute (ANSI) and International Standards Organization (ISO) standards
11. Mount toolholders
12. Set up/operate turning machines with index able tooling
13. Set turning feeds and speeds using shop formulas and charts
14. Select type of carbide to match a given application

Competency: Perform turning operations according to print specifications, dimensions, and tolerances L-1, 2.3 & 2.4

1. Mount/true workpieces in 3-jaw and 4-jaw chucks
2. Mount workpieces between centers
3. Mount workpieces in collets
4. Align centers
5. Face workpieces
6. Turn outside diameters
7. Turn workpieces to a shoulder
8. Turn inside diameter (ID) and outside diameter (OD) tapers
9. Knurl workpieces
10. Cut off workpieces using a parting tool
11. Cut workpieces using a form tool
12. Bore inside diameters
13. Cut right-hand and left-hand threads
14. Center-drill workpieces
15. Drill workpieces
16. Support long workpieces using a steady rest
17. Support long workpieces using a follower rest
18. Ream workpieces
19. Counterbore holes
20. Countersink holes
21. Chamfer workpieces
22. File/polish workpieces

23. Produce tapers
24. Perform tapping operations using a lathe
25. Pick up threads using a lathe
26. Sharpen cutoff tool blades

Unit 8: Milling Machines

Competency: Demonstrate basic knowledge of milling machine

1. Interpret terminology associated with milling machine
2. Identify types of milling machines
3. Identify major components of vertical and horizontal milling machines
4. Identify milling machine vertical and horizontal operations
5. Identify milling machine accessories for holding work
6. Identify milling machine accessories for holding cutting tools

Competency: Apply knowledge of general maintenance procedures

(manufacturers' specifications) for milling machines L-1, 5.1

1. Follow established safety procedures for milling machine maintenance
2. Identify general housekeeping and maintenance procedures for milling machines
3. Identify preventive maintenance procedures for milling machines
4. Identify tooling maintenance procedures for milling machines
5. Clean/lubricate milling machines
6. Check milling machines for wear and alignment
7. Check coolant level

Competency: Set up milling machines according to manufacturers' specifications L-1, 2.6

1. Select milling machine appropriate for a given job
2. Indicate milling machine heads
3. Select cutter appropriate for a given job
4. Mount tool holders and tools
5. Select speeds and feeds using shop formulas and charts
6. Select work-holding device appropriate for a given job
7. Mount/indicate work-holding devices
8. Mount/indicate workpieces
9. Select cutting fluid appropriate for a given job
10. Calculate cutting speeds and spindle RPM
11. Calculate feed rates in inches or meters per minute
12. Align workpieces mounted on a machine table
13. Identify ANSI and ISO standards for selection of cutter bodies and inserts
14. Identify established procedures for setting up/operating milling machines with index able tooling
15. Mount cutters and cutter holders for horizontal spindle milling machines

Competency: Perform milling operations according to print

specifications, dimensions, and tolerances L-1, 2.6

1. Mill flat surfaces
2. Mill angular surfaces by tilting milling head
3. Mill cylindrical workpieces
4. Mill square workpieces mounted in a vise
5. Mill external radiuses
6. Mill using power feed accessories
7. Mill keyways
8. Center drill and drill holes in workpieces
9. Bore holes using a boring head
10. Tap workpieces
11. Ream workpieces
12. Pick up edges or scribed lines using an edge finder, wiggler, or cutting tool
13. Secure workpieces in position using an angle plate
14. Monitor table movements using a digital readout accessory or micrometer dial
15. Identify uses of indexing heads
16. Identify types of gears
17. Identify applications of different types of gears

Unit 9: Grinding Machines

Competency: Demonstrate knowledge of general maintenance procedures (manufacturers' specifications) for grinding machines

1. Identify established safety procedures for grinding machine maintenance
2. Identify general housekeeping and maintenance procedures for grinding machines
3. Identify preventive maintenance procedures for grinding machines
4. Identify tooling maintenance procedures for grinding machines
5. Identify differences between maintenance procedures for various grinding machines
6. Identify procedures for care of grinding wheels
7. Identify procedures for use of coolants with grinding machines
8. Describe impact of abusive grinding procedures

Competency: Demonstrate knowledge of grinding wheels and dressing devices L-1, 2.7

1. Identify different types of conventional grinding wheels
2. Identify specifications for conventional grinding wheels
3. Identify dressing procedures for conventional and superabrasive grinding wheels

Competency: Operate pedestal and/or bench grinders

1. Follow established safety procedures for use of pedestal or bench grinders
2. Select grinding wheel appropriate for a given job
3. Ring test grinding wheels
4. Mount grinding wheels
5. Identify tools and materials that can be sharpened on a grinder

6. Sharpen tools using pedestal and bench grinders
7. Clean area in accordance with general practices

Competency: Operate surface grinders L-1, 2.7B

1. Follow established safety procedures for use of surface grinders
2. Select conventional grinding wheel appropriate for a given job
3. Ring test grinding wheel
4. Mount grinding wheels
5. Balance grinding wheels
6. Select dressing method appropriate for wheel condition and given job
7. Dress grinding wheels
8. Select work-holding device appropriate for a given job
9. Mount work-holding devices
10. Specify inspection methods
11. Set coolant flow
12. Grind parts
13. Inspect parts to verify tolerances and finish

Competency: Describe superabrasives

1. Identify when to use superabrasives
2. Identify advantages of superabrasives
3. Identify superabrasive dressing methods
4. Identify coolants used with superabrasives

Unit 10: Computer Numerical Control (CNC)

Competency: Demonstrate basic knowledge of computer numerical control (CNC) machines

1. Identify advantages and disadvantages of using CNC machines for different jobs
2. Identify basic components of CNC machine tools
3. Calculate coordinates and dimensions for CNC machines
4. Solve CNC problems using simple trigonometry

Competency: Prepare programs according to print specifications, dimensions, and tolerances

1. Demonstrate knowledge of basic functions of a machine control
2. Demonstrate knowledge of basics of data transfer (e.g., uploading and downloading of information)
3. Demonstrate knowledge of basics of conversational programming
4. Write programs in EIA-ISO G-Code formats
5. Demonstrate knowledge of programs using CAD/CAM systems

Competency: Set up/operate CNC milling machines

1. Follow established safety procedures for use of CNC milling machines
2. Maintain CNC milling machines
3. Edit speeds and feeds of program
4. Set tooling references
5. Dry-run CNC milling machines
6. Set coolant flow
7. Specify inspection methods
8. Mill parts using CNC milling machines
9. Inspect parts to verify tolerances and finish
10. Recognize various applications for clime and conventional milling

Competency: Set up/operate CNC turning machines

1. Follow established safety procedures for use of CNC turning machines
2. Maintain CNC turning machines
3. Edit speeds and feeds of program
4. Set tooling references
5. Dry-run CNC turning machines
6. Set coolant flow
7. Specify inspection methods
8. Turn parts using CNC turning machines
9. Inspect parts to verify tolerances and finish

Unit 11: Job Planning and Management

Competency: Identify planning and process procedures necessary for organization and production

1. Identify required milling, drilling, turning, and grinding procedures for a project/job
2. Formulate a set of strategies to manufacture the part

Competency: Organize the workplace

Key Indictors:

1. Identify machine tools, hand tools, measuring tools, fixtures and work materials needed for the project/job
2. Complete an operational sheet detailing the process plan and required speeds and feeds

*****This competency profilet has been correlated with the National Institute for Metalworking Skills, Inc. (NIMS) Machining Skills Standards for Credentialing, Level 1 and Level 2 (L1 or L2).**

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